



American Architectural Manufacturers Association

DOE R-5 Program Challenges Window Designers

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With evolving codes and standards driving window performance ratings higher, insulating glass producers and window manufacturers are challenged to build units in the most efficient manner possible to achieve cutting-edge performance ratings, such as those required under the Department of Energy's (DOE) R-5 window program ($U = 0.20$ for fixed windows, 0.22 for operable windows). By comparison, typical ENERGY STAR® windows have an R-value of 3. According to the DOE, increasing the R-value from 3 to 5 reduces average heat loss through the windows by 40% and saves consumer money on energy bills. However, meeting this challenge will likely involve rethinking designs and the selection of window components to include more advanced technologies that offer higher thermal performance.

Because price is the principal barrier to more widespread market commercialization of R-5 windows, the aim of DOE's R-5 Volume Purchase Program is to work with industry and potential buyers to make highly-insulated double- and triple-glazed windows more affordable.

Over the past year, the Volume Purchase Program has developed interest from the window industry, and after the Phase I Windows Volume Purchase RFP process (released December 18, 2009 and closed on February 19, 2010), more than 50 qualified manufacturers were named as eligible.

As of January 2011 DOE announced the opening of Phase II of the R-5 program for participation by more manufacturers and suppliers of R-5 products. [Final specifications](#) and a [request for proposals](#) are available online.

The program unfolds in three basic steps:

- Based on the specification, interested manufacturers bid in response to the RFP. Responses to the RFP will be due on March 18, 2011, with products from the certified vendors to be listed on the Phase II website by late May. Responses to the RFP will be accepted after March 18 and will be evaluated after those responses received on or before March 18 are processed.
- Successful bidders are chosen based on meeting technical specifications. Their products are listed on a purchasing website with their listed price available for both buyers and other manufacturers to see.

- Customers then have the opportunity to purchase the listed products from that website at the listed prices. The prices are 'base' prices bid into the program and do not include delivery, installation and other features such as grids. Vendors may also offer high performance windows (R-5/U-0.22 for operable windows) with other frame materials and/or colors, and the price for those windows may be different than the base price offered through this program. Manufacturers can lower their price at any time, but may not raise it, and are able to delist products at any time.

R-5 Design Considerations

To meet the R-5 challenge, the entire suite of available thermal improvement technologies should be considered in an appropriate mix. There are – as is often the case – trade-offs inherent in hitting the cost vs. performance “sweet spot” that will vary from company to company.

Ric Jackson, director of marketing and business development for Truseal Technologies Inc., a Quanex Building Products company, penned a thorough assessment of what goes into a design to achieve R-5 ratings, as well as some of the inherent tradeoffs. The article, *R5 Triples or R5 Doubles?*, appeared in the September 9, 2010 issue of [Window & Door magazine](#), and many of the points that follow and the diagrams are based on that article.

Insulating Glass

The starting point is obviously insulating glass. Whether the configuration is based on double-glazing or triple-glazing depends on the relative “bang for the buck” obtained from the other IGU features employed, such as inert gas infill, spacer type and glass coatings.

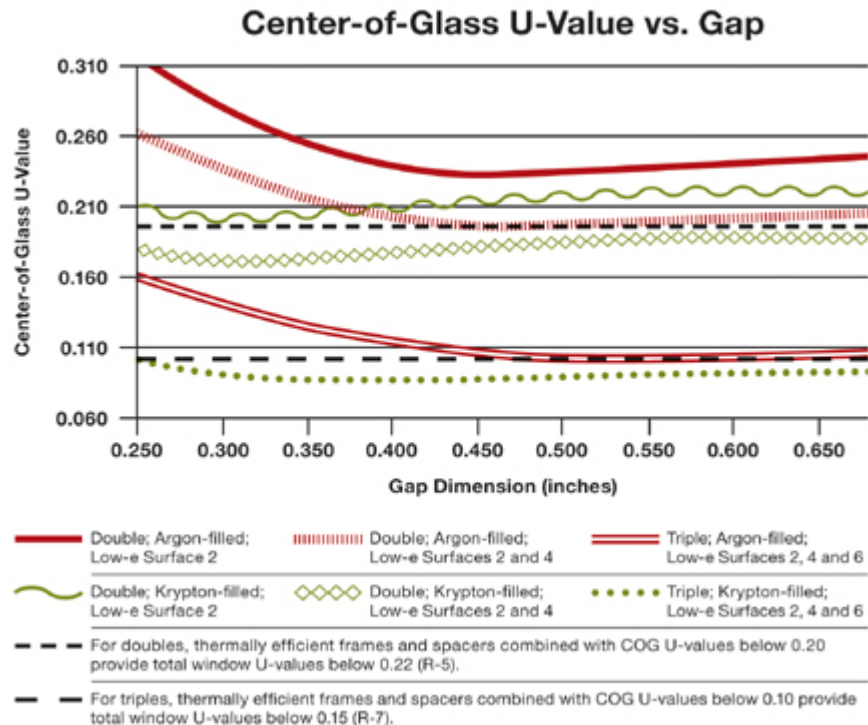
Gas Filling- Filling insulating glass unit (IGU) airspaces with gas is a necessity in a double-glazed window to push it over the R-5 threshold, but not necessarily in a triple. However, the low cost-to-thermal-benefit ratio of argon makes it a desirable addition to most products. Argon may enable a 0.04 U-value improvement in a double for as little as 1 percent of the total raw material cost. Krypton and xenon offer even greater U-value improvements, but their high cost makes them harder to justify. An advantage of gas filling in a triple is that manufacturers can fill both airspaces for optimal thermal performance.

Spacers- Spacers that utilize “warm edge” technology are typically utilized to meet R-5 requirements. With triples, manufacturers essentially double their spacer costs compared to double-pane windows. In addition, the extra spacer profile in a triple creates an extra moisture vapor transmission path, which is an additional point of potential failure in each window.

Double glazing- If double-glazed IGUs are to rise to the R-5 level, wider cavities between the two glass panes are recommended, with 5/8-inch considered by many to be the optimum separation. Compared to simple “conventional” double glazing as a baseline, the most advanced double pane IGUs bearing such key technical advances as inert gas infill and low-emissivity glass coating typically reduce U-value by 34 percent, while an advanced triple-pane “super window” can be 60 to 70 percent lower (39 to 54 percent lower than the advanced double-glazed).

Even when using krypton as the infill gas (instead of the more common argon), manufacturers

are not able to realize R-5 values in a traditional double. Figure 1 shows that the best possible center-of-glass (COG) U-value is just above 0.20 in a double featuring a 0.018 low-E coating on glass surface 2, krypton gas filling and high-performance spacer and frame systems. That COG U-value results in a total window U-value of 0.23 or R-4, per the program's specifications.



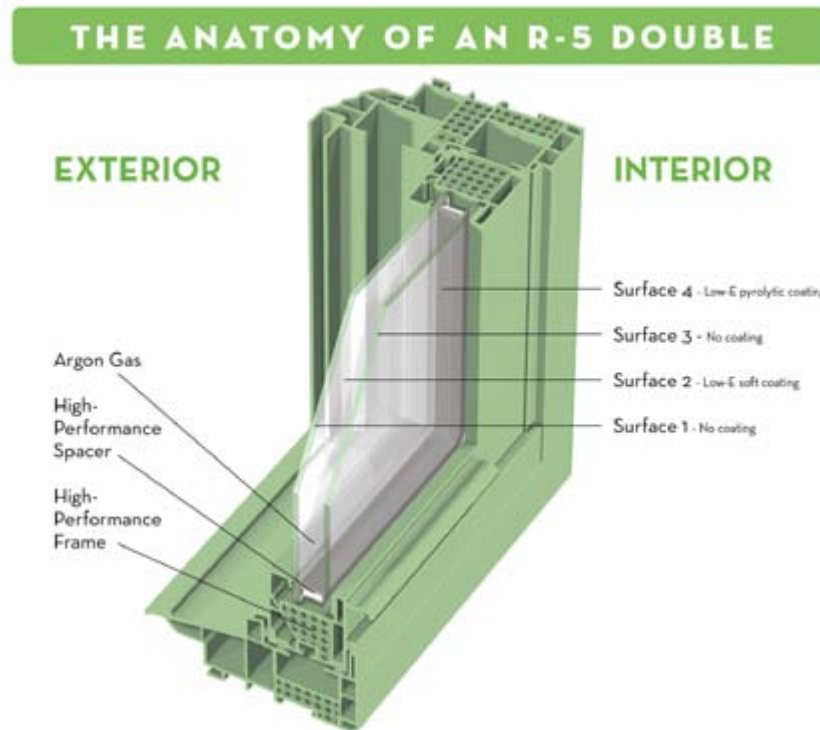
However, by applying low-E coatings to two of the glass surfaces in a double (the same 0.018 low-E coating on surface 2 and a pyrolytic low-E coating on Surface 4), manufacturers are able to achieve R-5 values using lesser expensive argon gas (see Figure 2). The design reduces center of glass (COG) U-values to 0.20, resulting in an R-5 (0.22 U-value) window. Applying this same concept to argon-filled triples—with 0.018 low-E coatings on Surfaces 2 and 4 and a pyrolytic coating on Surface 6—drops COG U-values to 0.10, yielding an R-7 (0.15 U-value) window. Naturally, krypton provides further COG U-value reductions, but with added cost.

Another potential tradeoff within this context relates to surface temperature. The coating on Surface 4 reflects heat back into the home, minimizing the amount of radiant heat passing through to warm the interior glass surface (Surface 3). The cooler interior surface may increase the potential for condensation inside the home.

Triple Glazing- Reaching the R-5 target with triple glazing is relatively easy. Already widely used in very cold climates, newer triple-glazed designs and tighter performance requirements can make it viable in more moderate climates as well. By specifying low-conductivity spacers, gas filling, thermally enhanced frames and two lites of very low-E glass, manufacturers can produce triples with U-values as low as 0.15 (R-7). Consequently, the marketplace is beginning to take a serious second look at triple glazing, heretofore more or less automatically thought of as too

expensive for the energy efficiency it provides. However, triple glazing is now said to be available at a price premium of only five to ten percent compared to double glazing, which can vary depending on features and materials, according to the DOE.

Although adding more panes alone doesn't decrease the unit U-value significantly in comparison to double-glazing, the extra airspace alone creates an additional barrier to heat transfer and enables improved thermal performance. It also gives manufacturers another option for gas filling. The extra lite also provides two additional coating surfaces, which enables room for further improved thermal efficiency—albeit at an added expense.



Jackson also cautions: “A triple with high-performance spacer and frame systems can meet the 0.22 U-value target without using krypton, as long as producers adhere to the 3-millimeter grid proximity rule. Triples should have a minimum air space of 3 mm between internal muntin bars and the glass to minimize heat transfer from one lite through the grid to the opposite lite.

Because of frame width limitations, manufacturers may need to employ an offset triple design in which one glazing cavity is wider than the other. Neglecting the 3 mm grid proximity rule may force manufacturers to use krypton to achieve R-5 values, which significantly increases costs.”

Because of their added weight, triples often require heavier-grade hardware compared to doubles in order to meet operating force guidelines within AAMA/WDMA/CSA 101/IS.2/A440. For example, manufacturers may need to specify heavier-duty spring balances for double-hung triples and stronger arms and hinges for triple casement windows.

Also, the extra lite of glass as well as the advanced and heavier-duty components means extra material cost, plus additional storage, handling, washing and processing, each of which represents potential cost increases. A manufacturer should compare the cost differential between the two options. Each component adds cost elements, but choosing the optimal combination can reduce the overall manufactured cost.

Despite how cleverly manufacturers focus on the R-5 target, they should realize that it will not likely be the end of the story. They also need to consider the inevitable trend toward even tighter energy efficiency standards and consumer demand that will go beyond R-5, including ratings that are harder to achieve economically in a double-glazed product, if at all. As Jackson observes, “Manufacturers opting to meet today’s requirements with them may be delaying an inevitable transition to production of triple-glazed units in the future.”

Please note that the current scope of the DOE R-5 Window Volume Purchase Program as well as the energy savings and product uses described in this article only applies to residential applications.

Figures 1 and 2, Courtesy of [Window & Door Magazine](#)